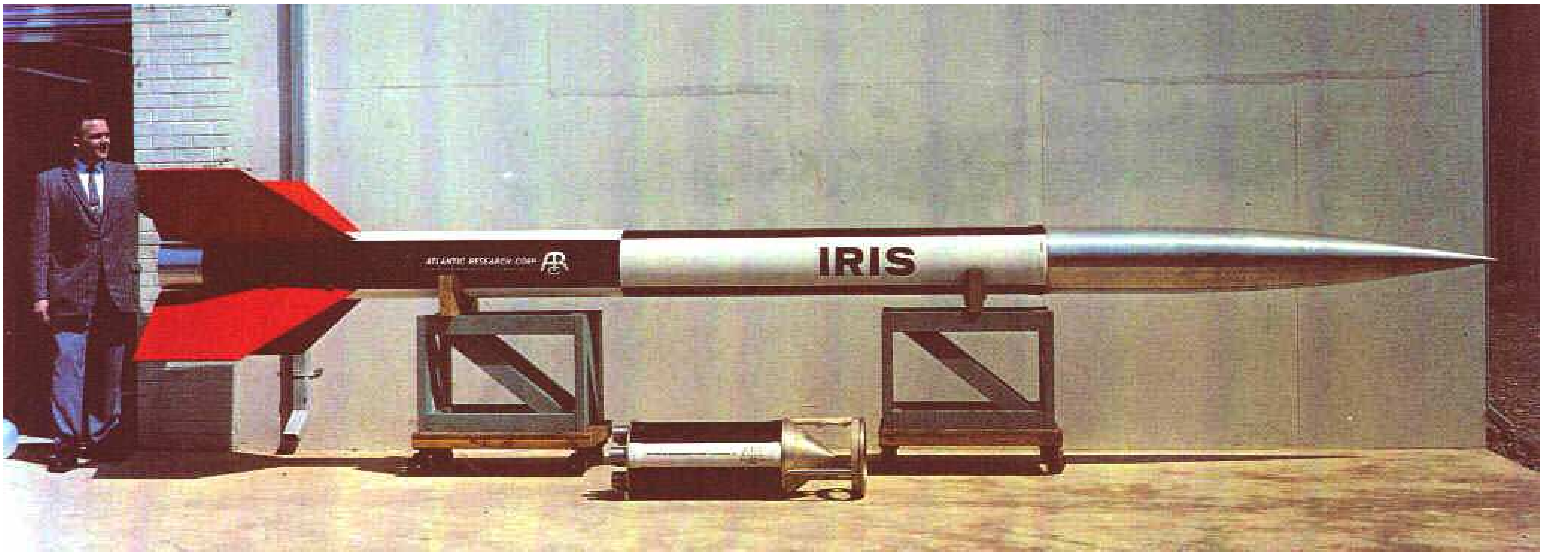
Level 3, Atlantic Research Corporation IRIS



UKRA pre-flight data capture for a level 3, Atlantic Research Corporation IRIS

1. **Name of principal flyer:-** **David Andrew Thomson**
2. **Phone number:-** **0151 339 7257**
3. **Alternate phone number (Mobile):-** **N/A**
4. **Email address:-** **dat@ngat.com**
5. **UKRA membership number:-** **1048**
6. **Address:-** **24 Church Lane, Great Sutton, South Wirral**

7. **Proposed launch date:-** **12t attempt KLOB 2005, 2nd attempt IRW 2007**
8. **Proposed launch location:-** **1st attempt Sleaford, 2nd attempt Fairlie Moor**
9. **STC project advisor:-** **Pete Davy, SRO on 1st attempt Charles Simpson**

The section below documents the proposed rocket in accordance with the requirements of the UKRA data capture forms. Drawings, schematics and calculations have been included with this data capture.

10. Project Overview

My Level 3 IRIS shall be a large ‘sport’ scale model. Limited scale data is available for this rocket in both textbooks and on the web. I have been in contact with the Goddard Space Flight Center and they have been able to give me some additional information to enable a more scale model to be made.

Basic parameters will be HyperTEK (Armageddon) ‘M’ class Hybrid motor. A minimum of two deployment systems for both drogue and main shall be used. A single drouge and a single main chute shall be used.

3mm-wall plastic ducting shall be used for the airframe. The nose cone shall be home made on a lathe using discs of pink foam covered with fibreglass. Both parachutes shall also be home-made.

Fin strength has been an issue on a few high power flights in the past and I shall be using Dibond for strength rather than Foamex. Root fixing of the fins shall be scale bolt on brackets using aluminium square section bar.

The whole rocket uses mechanical fixings for strength. No glue is used in stress areas. The rocket may be disassembled for inspection and maintenance.

11. **<u>Source - kit or scratch</u>**

As stated in 10 above, the whole rocket including nose cone, formers, fins and payload bays are scratch built.

- Body is 200mm diameter plastic ducting 3mm wall thickness
- Fins are Dibond (Aluminum and plastic sheet composite material)
- Nose cone is home made using pink foam, turned on a lathe and covered with fibreglass
- Bulkheads are ¾ inch and ½ inch plywood

12. **<u>Total rocket length.</u>**

The rocket is approximately 2/3 scale and is 157 inches long.

- IRIS scale data table

Scale	NC	NC Ratio	Diameter inches	Length Inches	Fins
Full	Ogive	6:1	12	238	4
3/4	Ogive	6:1	9	178.5	4
2/3	Ogive	6:1	8	158.66	4
1/2	Ogive	6:1	6	119	4
1/3	Ogive	6:1	4	79.33	4
1/4	Ogive	6:1	3	59.5	4

13. **<u>Rocket diameter</u>**

The rocket is 8inches (200mm) in diameter

14. **<u>Total rocket weight (include everything except the motor weight)</u>**

Rocket weight without motor is 53lbs

15. **<u>Flight number.</u>**

This will be issued on the day of the flight at UKRA 2003

16. **<u>Avionics description.</u>**

A minimum of two deployment systems for both drogue and main shall be used. Both of these systems shall be mounted in the centre payload section as detailed on the attached drawings.

Batteries shall be positively mounted within the same payload section. The mountings for the batteries shall be capable of withstanding both launch and deployment forces.

A single drouge and a single main chute shall be used.

17. Recovery actuation description.

Recovery actuation shall be by activation of electric matches (Davy fire) from both the deployment systems at apogee and then at a predetermined altitude for main.

Actuation at apogee shall be two charges by each system (4 x charges for agogee). Tow charges by each system shall be used for main deployment (4 x charges in total). Each charge black powder is contained within a plastic tube mounted upon bulkheads either side of the deployment electronics payload.

Devices used for deployment shall be two G-Whizz deluxe systems operating in parallel.

18. Motor type.

HyperTEK Armageddon M Hybrid motor shall be used. Detailed information is given in the tables below. I have two fuel grains for this motor. A standard grain and a HyEFX grain. I intend to use the HyEFX grain on the flight proposed.

MFR	Configuration*	Total	Max.	Max.	Total	System	System	Liftoff	Propellant	Burnout
#		Impulse	Thrust	Thrust	Burntime	Dimensions	Dimensions	Weight	Weight	Weight
		Ns	N	lbs.	s	mm	in.	g**	g	g**
M1010	4630/98-RG-MFX	9114	2063	464	9.1	98 x 1405	3.860 x 55.300	8949	4301	4648

Tank size	Bell	Orifice	Grain*	Motor Designation	Total impulse, Ns	Burn time
4630cc	RG M		M	M1000	9155	9.1
			M-FX	M1010	9114	9.1

* meaning of grain designations:
M Standard M grain
M-FX HyEFX M grain

19. Method of ignition.

Ignition shall be none pyrotechnic using standard HyperTEK ground support equipment.

20. Launcher type - rod, rail or tower.

The rocket shall be launched from a homemade long rail system. This has been successfully used for many K flights and K to J staged flights with rockets of 30lbs+. I believe the launch rail is capable of launching the proposed rocket.

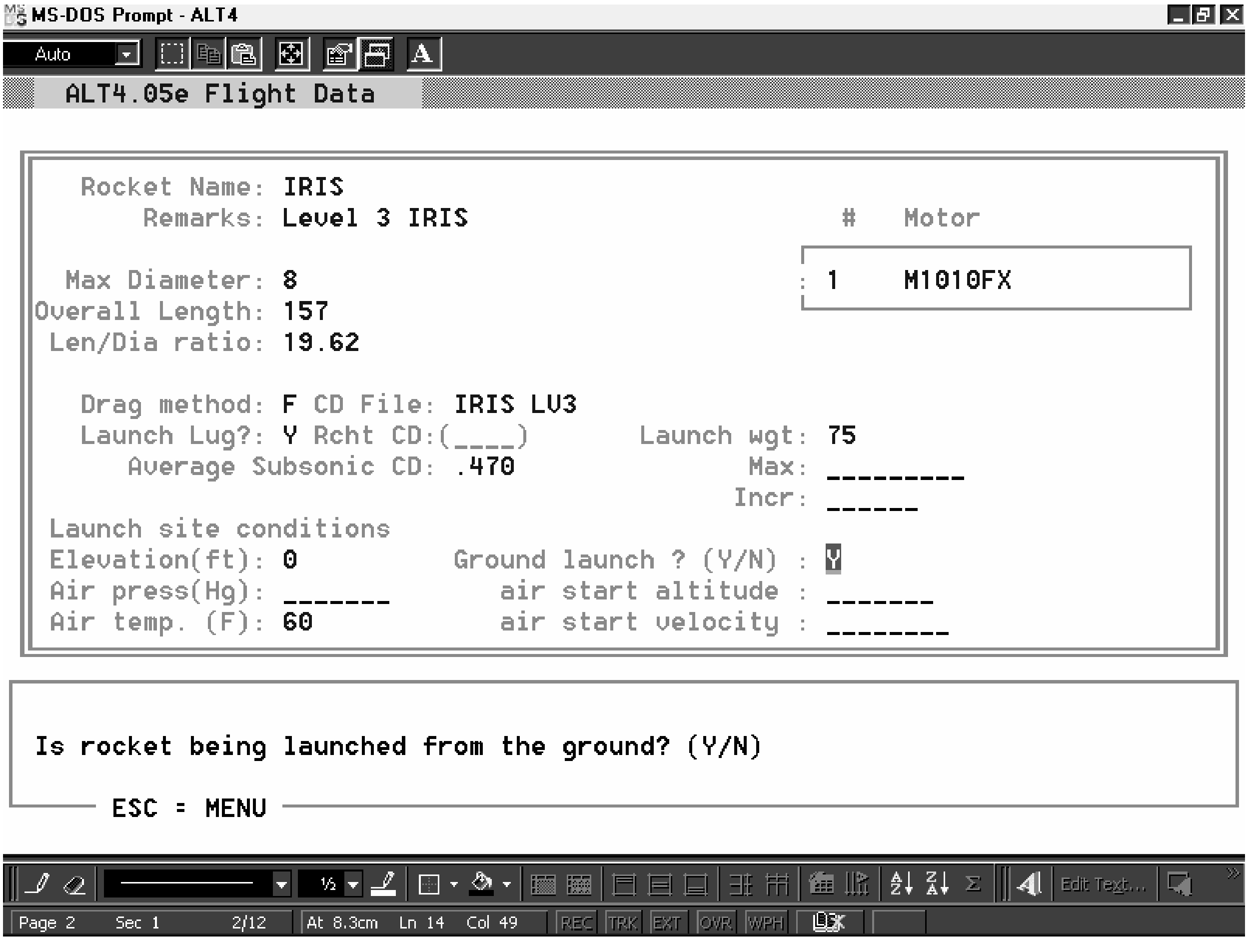
21. <u>Stability margin - including how calculated.</u>

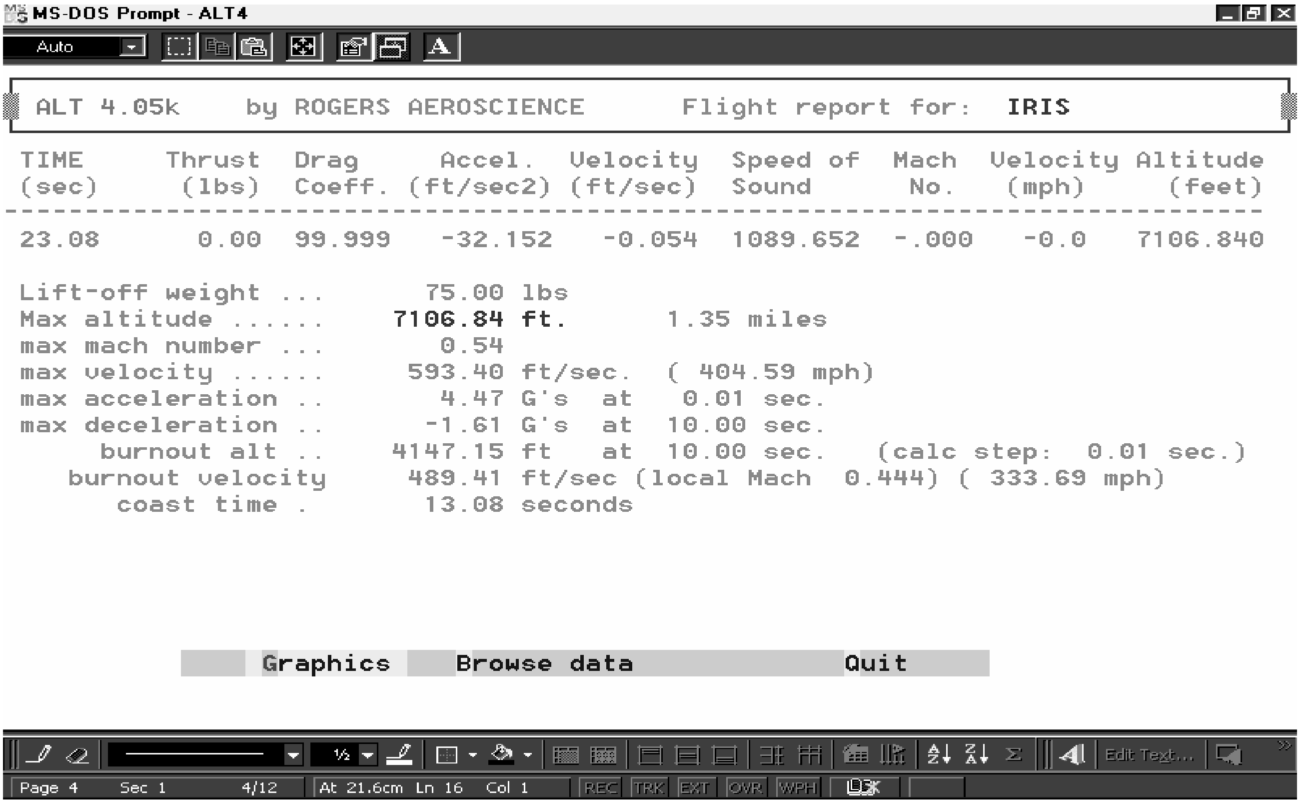
Stability margin is geater than 2 calibre. This will change during flight due to the nature of the burn for Hybrid rocket motors. This was calculated with Rogers Aeroscience computer software and confirmed by my own calculations from formulae obtained from High Power Rocketry magazine.

22. <u>Calculated altitude - including how calculated.</u>

Rogers Aeroscience computer software predicts that the rocket will reach an altitude of 7107 feet

A number of printouts form the Rogers Aeroscience computer software program have been included.





MS-DOS Prompt - ALT4

ALT 4.05k by ROGERS AEROSCIENCE Flight report for: IRIS

TIME (sec)	Thrust (lbs)	Drag Coeff.	Accel. (ft/sec2)	Velocity (ft/sec)	Speed of Sound	Mach No.	Velocity (mph)	Altitude (feet)
23.08	0.00	99.999	-32.152	-0.054	1089.652	-.000	-0.0	7106.840

Lift-off weight ... 75.00 lbs
Max altitude ...... 7106.84 ft. 1.35 miles
max mach number ... 0.54
max velocity ...... 593.40 ft/sec. (404.59 mph)
max acceleration .. 4.47 G's at 0.01 sec.
max deceleration .. -1.61 G's at 10.00 sec.
burnout alt .. 4147.15 ft at 10.00 sec. (calc step: 0.01 sec.)
burnout velocity 489.41 ft/sec (local Mach 0.444) (333.69 mph)
coast time . 13.08 seconds

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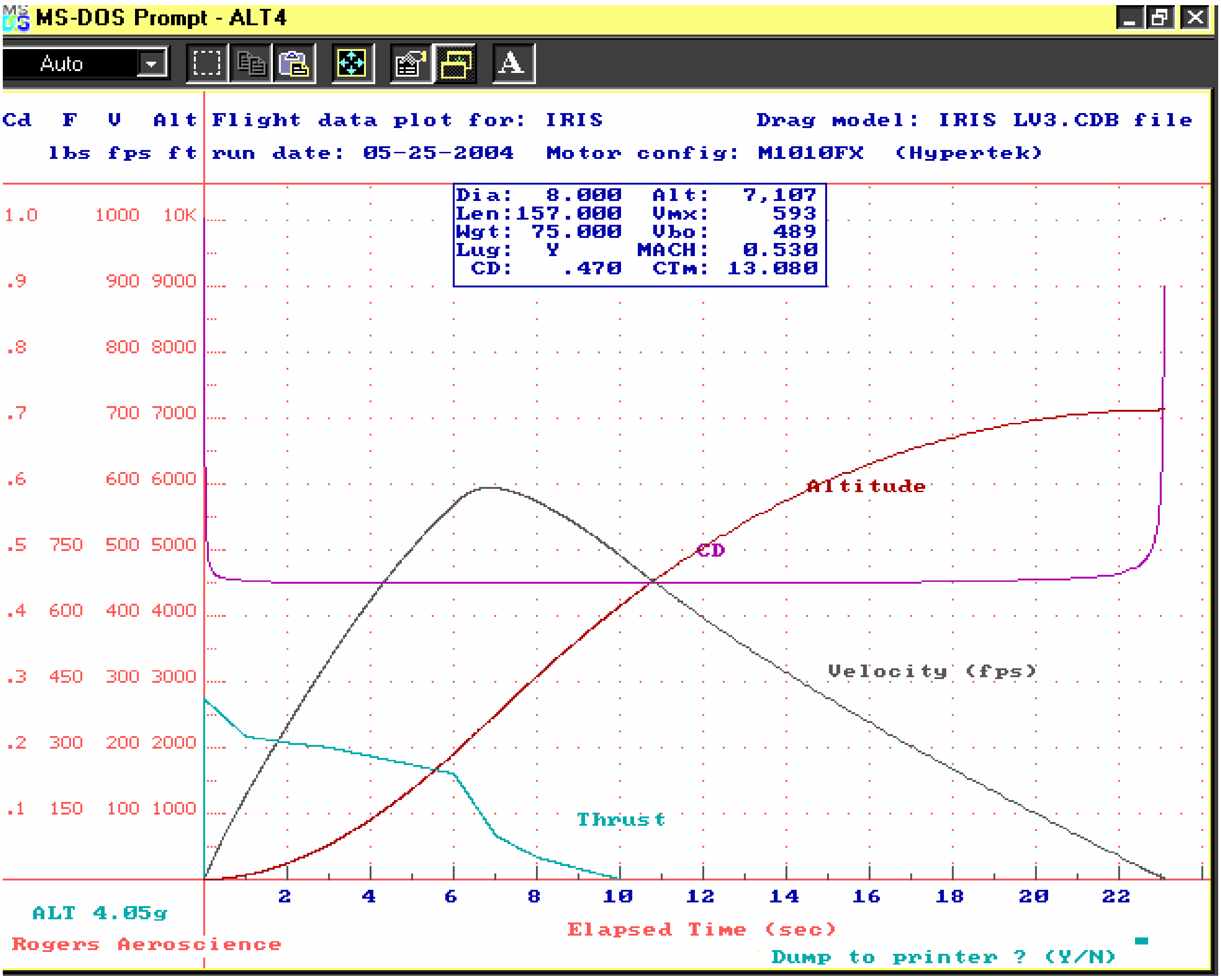


23. Calculated velocity - including how calculated.

Rogers Aeroscience computer software predicts that the rocket will reach a maximum velocity of 404.6mph.

24. Estimated maximum recovery range.

The following is extracted from the UKRA recovery table:-

Total Impulse of all Motors (Newton-seconds)	Equivalent Motor Type	Minimum Site Dimensions in Meters (ft)	Equivalent Dimensions in km (miles/yards)
5,120.01 -- 10,240.00	M	4700 (15,420)	4.7 km (3 Miles)

Dual recovery systems normally mean that the rocket will be recovered well within the required dimensions of the recovery area. This is mainly dependent on the wind speed of the day. I do not intend to launch in winds in excess of 5mph. My intention is to launch in wind speeds lower than this.

25. Pre-flight assembly plan - including any tests to be completed on site.

The following is extracted from HyperTEK documentation.

Motor Preparation

- Install new o-rings carefully for the Kline valve and injector. Lubricate the set of new o-rings with small amount of the supplied lubricant, and install in place. Use *Hyper*TEK® lubricant only – do not use fluorinated lubricants such as Krytox.

- Igniter Installation:-

  With M motors, the preferred method is to tape the igniter wire to the core of the fuel grain before motor assembly. It has proven reliable both on the test stand and in the field.

  A 24” piece of the supplied igniter wire is cut. The end that is to be placed in the motor is cut cleanly and straight across. A sloppy cut can reduce reliability, causing ignition delays or preventing ignition altogether.

  A strong electric arc is required for quick reliable ignition. Quality tests shall be done as described in the GSE checkout procedure. The insulation shall be stripped from the other end, and twisted together to avoid fraying.

  A strip of vinyl electrical tape about 3” long is cut and placed lengthwise on the motor end of the igniter wire, with about ½” of the wire remaining exposed.

  The other end of the igniter wire is fed down through the top of the motor grain and out the nozzle. The wire is pulled down gently until the top of the wire is about ¾” from the top of the core and the very top of the fuel grain.

A step can be seen in the internal bore of the fuel grain, a little way in from the forward end of the motor. At this point the inside diameter reduces slightly. The igniter shall be installed about ¾" further in from that point.

The tape shall be smoothed down to the wall of the fuel grain core. The wire shall be slightly bent so that it stands 1/8" off from the inside wall of the grain.

You may now proceed with motor assembly. The remaining igniter wire shall be secured to the nozzle end of the motor with a piece of tape, to keep it out of the way and to keep it from catching anything and getting pulled out during assembly and preparation for launch.

- Fit the flexible polyurethane vent tube if used. Trim as necessary. Push the end of the tubing firmly into the fitting, then pull gently to ensure the fitting has grabbed onto the tubing.

The HyperTEK motor is now ready for installation into the IRIS.

Ground Support Equipment (GSE) Assembly

- Mount the nitrous oxide solenoid assembly onto the nitrous oxide tank. The tank fitting which connects the tank valve to the solenoids should be moderately tight - a large adjustable wrench is suggested, NOT slip-joint pliers. Attach the nitrous oxide line (the hose with the blue 4AN fittings). Take care not to overtighten the aluminum AN fittings; a small amount of torque is sufficient to effect a seal.

- Mount the GOX assembly on the oxygen tank. Attach the oxygen line (with red AN fittings) to the regulator. The fitting tightening instructions above apply here as well. It is recommended that the oxygen bottle be laid on its side to prevent damage to the valve or regulator in case it is knocked over. The aluminum hose fittings are also particularly susceptible to this type of damage. Remember that oxygen is stored as a compressed gas and thus tank orientation is unimportant.

- Mount the launch stem assembly to the launch rod or rail, following the separate instructions provided. Connect the nitrous oxide line (blue fitting) to the nitrous oxide fitting on the launch stem (blue fitting). Connect the oxygen line (red fitting) to the oxygen fitting on the launch stem (red fitting). The oxygen tank and the nitrous oxide tank should be six to eight feet from the launch stand, with no kinks or tight bends in the hoses.

- Connect the satellite control box to the launcher. The box has two duplex outlets. The duplex outlet with brown and white outlets is for the nitrous oxide solenoids. The black outlet is for the ignition module, and the green outlet is for the oxygen solenoid. Plug the nitrous oxide dump solenoid (*white* plug) into the *white* nitrous dump outlet. Plug the nitrous fill solenoid (*brown* plug) into the *brown* nitrous fill outlet. Plug the oxygen solenoid (*green* three-prong plug) into the *green* ignition oxygen outlet. Plug the ignition module (*black* three-prong plug) into the *black* ignition spark outlet.

- Plug the satellite control box onto the extension cord, and run the extension cord to the test or launch control area. Plug the extension cord into the launch controller.

- Connect the launch controller to your 12 volt battery. The controller is equipped with polarity protection - it does not matter which clip goes to which battery terminal. The system is now ready to operate. Before testing the GSE, double-check that the oxygen hose is attached to the oxygen fitting on the launch stem assembly, and that the nitrous hose is

attached to the nitrous fitting. Also, check to make sure that the nitrous fill and nitrous dump solenoids are plugged into the correct outlets on the satellite control box.

- **REMEMBER REMEMBER**: Blue fittings are used for nitrous oxide and red fittings for oxygen.

Testing the GSE

When first testing your GSE, the following procedure should be performed outside in a clear, ventilated area free of open flame, dry grass, etc. **Do not** test oxygen or nitrous oxide delivery systems indoors! This same procedure can and should be carried out in the field whenever the GSE is assembled for launching purposes. Testing first can save aggravation later.

- Split and strip insulation from one end of a 4 inch piece of ignition wire. Twist the stripped wire ends to avoid fraying. Cut the other end straight across – make this a clean cut with sharp scissors or cutters.

- Attach the stripped ends to the alligator clips of the ignition ignition module, and let the cut end dangle where it is visible. Make sure that the alligator clamps are not shorted together and that the wire or the clips are not in contact with you or anything else.

- Fully open the oxygen tank valve and adjust the regulator to between 80 and 100 psi. If you hear any leakage, turn the oxygen off and make sure the fittings are tightened.

- Fully open the nitrous oxide tank valve and verify that there are no leaks. Remember that nitrous oxide tanks without siphon tubes must be mounted upside down to allow liquid nitrous oxide to flow into the oxidizer tank.

- Set launch controller switches as follows: Safe/Arm key switch on **Safe Safe**, rotary switch on **Fill** (top) position, and activate switch **Off Off**.

- Attach the battery cables to a 12V DC source capable of supplying at least 10 amps. Either a car battery or a gel-cell battery will be adequate. Please note that the launch controller circuitry is reverse-polarity protected and the clips may be attached either way to the power source.

- Turn the Safe/Arm key switch to the **Armed** position. The indicator light should now be on.

- Make sure that the launch pad area is clear prior to checking the oxidizer fill system. Briefly push the activate toggle switch up and nitrous oxide should be released from the launch stem. As nitrous oxide escapes from the fill tube, the vaporizing liquid plume should be easily visible. Release the toggle switch.

- Move the rotary switch to the dump position, and activate the toggle switch. The dump solenoid clicks as it opens – listen for the sound (no nitrous oxide will be released). Release the toggle switch.

- Double check that the ignition wires are clear of any part of the GSE or other materials, and especially away from you! Move the rotary switch to the fire position, and activate the toggle switch. A steady high-voltage arc should be seen at the end of the ignition wire, and oxygen should be heard escaping from the start oxidizer tube. **Do not** place any part of your

body near the ignition circuitry while this test is in progress – serious electric shock could result.

This completes the GSE checkout procedure.

26. <u>Launch sequence operations.</u>

The rocket shall be launched under the requirements of the UKRA Safety Code.

In addition, the launch shall be in accordance with the HyperTEK requirements. The sequence below has been extracted from HyperTEK documentation.

<u>Launch Sequence (HyperTEK)</u>

Set up your launcher and ground support equipment (GSE) as described earlier.

- Test the GSE before proceeding.

- Refer to the specific assembly and use instructions for your motor type, included in this manual. Select orifice (if required) and assemble your *Hyper*TEK® motor. Make sure fresh o-rings are used, and that they are properly lubricated and fitted.

- Load motor into rocket. Prepare rocket and recovery system electronics for launch.

- Cut a piece of igniter wire about 24” long. Separate the wires at one end and strip about ½” of insulation from each. Twist each wire end to prevent fraying.

- Tape the igniter wire to the launch stem as shown leaving a little extra at the top so you can trim the top end of the wire about 1” from the top of the nitrous oxide fill tube. Trim the wire by making a clean, straight cut as you did for GSE testing, double checking that the cut end is positioned about 1” from the top of the fill tube. Bend the cut end outward slightly.

- Slide the rocket down the launch rod or rail. Carefully feed the launch stem up through the fuel grain. When the fill tube (the center coaxial tube) passes through the Kline valve o-ring, you should be able to feel it seat against the injector body.

- Feed the tie-straps through the slots in the fuel grain, and loop one around each protruding bolt on either side of the stop collar on the drop stem as shown at right. Join the tie-strap ends and cinch them up tightly to pull the drop stem firmly towards the motor.

- Raise the launch rod or rail to launch position, and arm the recovery electronics.

- Fully open the nitrous oxide and oxygen tank valves. If you hear any leakage, STOP, and fix the problem before proceeding. Your *Hyper Hyper*TEK TEK® hybrid powered rocket is now ready to fill and launch!

- Secure permission from the Range Safety (RSO) and Launch Control Officer (LCO) to proceed with tank fill and launch. Make sure that the RSO and LCO are aware of the time required to fill the tank and understand that launch should occur immediately after filling.

- Arm the launch controller by turning the key switch to the “Armed” position.

- Fill the tank by turning the Launch Controller rotary switch to “Fill” and pushing up on the activation switch. You will hear a hissing sound as gaseous nitrous oxide rushes out the vent tube.

- When the tank is full, you will see a visible plume of nitrous oxide vapor issuing from the vent tube. Listen carefully, as you will hear a change in the sound, which can be helpful to identify when the tank is full. Release the activation switch when the tank is full.

- Signal the LCO that you are ready to fire, and turn the rotary switch to the “Fire” position.

- The LCO should now begin the countdown.

- When the count reaches zero, press up on the activation switch and HOLD IT THERE until the rocket launches. You can expect the rocket to remain on the pad for a couple of seconds while the GOX begins to flow, igniting the fuel grain, from which the flame front will take a moment to burn the tie-straps. When this happens, the rocket will immediately lift off.

- Release the activation switch, and disarm the controller.

The spent fuel grain CANNOT BE REUSED and should be discarded. To fly again, simply repeat the above procedure with a new fuel grain and o-rings.

27. <u>Payload</u>

The IRIS rocket shall carry a live video down-link to the launch site. The system has been used on many occasions on other rockets that I have flown. The system does not interfere with launch systems or avionics recovery. The system is 2.4Ghz and is license exempt.

The transmitter is housed within the nose cone. Data is transmitted via a short helical antenna to the ground receiver. Both colour video and sound are transmitted.

The data is recorded at the launch site by helical antenna and stored on video. A CCTV monitor is used to verify signal reception and recordings.

The payload section shall also include a tracker system and an audible warning siren. The siren, tracker and video down-link systems shall be activated just after the rocket has been assembled onto the launch pad, just prior to launch.

28. Brief History of the IRIS

The Aerobee 150, Aerobee-Hi, Argo D-4 (Javelin), Argo D-8 (Journeyman), Astrobee 200, Astrobee 250, Astrobee 1,500, Black Brant (Canadian, named for a Canadian goose), IRIS, Nike, Nike-Tomahawk, and Nike-Black Brant were all sounding rockets developed to conduct atmospheric research.

The Iris sounding rocket was launched mainly between 1960-1962. The Nike-Tomahawk was first launched in 1965. The first Thor based launch vehicle was the Thor-Able. The Able upper stages were the upper stages from Vanguard, essentially an Aerobee topped by an ABL X-248. Several minor variants were flown to test Atlas reentry vehicles and later some lunar probes. Able Star followed and was the first space-restartable upper stage.

The development of the Iris sounding rocket had begun at NRL prior to the transfer of its Rocket-Sonde group to NASA. Iris was built by the Atlantic Research Corp. for the Naval Bureau of Ordnance, with NRL monitoring the design, the production, and the payload.[58] The development of the rocket was completed by NASA, with the first NASA firing taking place at Wallops Island on July 22, 1960. In contrast to the monsters in the Argo series, Iris is a small, two-stage, solid-propellant rocket capable of lifting 45 kg (100 lb) to about 320 km (200 mi). NASA has not used the Iris rocket since 1962.

1960 Jul 22 - Launch Site, Wallops Island

The first flight of NASA's Iris sounding rocket was successful and rose to an altitude of 224 miles.

Launch_Tag	Year	Month	Day	Type	Flight_ID	ght	Platform	Launch Site	Apogee in Miles	Agency	Category	LTCite
1960-R4113-001	1960	Jul	22	Iris	NASA 5.01GT		-	WI	224	NASA	Aeronomy/Test	WDCRF
1960-R4113-002	1960	Oct	18	Iris	NASA 5.02GT		-	WI	225	NASA	Aeronomy/Test	WDCRF
1961-R4113-001	1961	Jan	19	Iris	NASA 5.03GT		-	WI	138	NASA	Aeronomy/Test	WDCRF
1962-R4113-001	1962	May	3	Iris	NASA 5.04GA		-	WI	113	NASA	Aeronomy	WDCRF
1964-R4113-001	1964	Aug	10	Hydra-Iris	GSP-1	GSP-1	T-AGM-8	POR6	200?	LRL/NMC	Magnetospheric	UCRL-50587
1965-R4113-001	1965	Jan	7	Hydra-Iris	SAP-1	SAP-1	T-AGM-8	AOR5	0?	LRL/NMC	Ionos/Mag	UCRL-50587
1965-R4113-002	1965	Jan	26	Hydra-Iris	SAP-2	SAP-2	T-AGM-8	AOR6	289	LRL/NMC	Ionos/Mag	UCRL-50587
1965-R4113-003	1965	Oct	28	Hydra-Iris	BOX-2	BOX-2	T-AGM-8	POR1	194	LRL/NMC	XR Astron	FDS
1966-R4113-001	1966	May	31	Hydra-Iris	BOX-4	BOX-4	T-AGM-8	POR2	188	LRL/NMC	XR Astron	FDS
1966-R4113-002	1966	Oct	30	Hydra-Iris	BOX-5	BOX-5	T-AGM-8	POR3	3	LRL/NMC	XR Astron	FDS
1968-R4113-001	1968	Mar	20	Hydra-Iris	BAR-1	BAR-1	AVM1	POR14	200?	LRL/NMC	Test	FDS
1968-R4113-002	1968	Nov	3	Hydra-Iris	BOX-15	BOX-15	T-AGM-8	POR5	227	LRL/NMC	XR Astron	FDS

Images of the IRIS

Upper coupler bulkhead

Lower coupler bulkhead

Motor mount upper centring ring

Image shows location of the bulkheads and centring rings

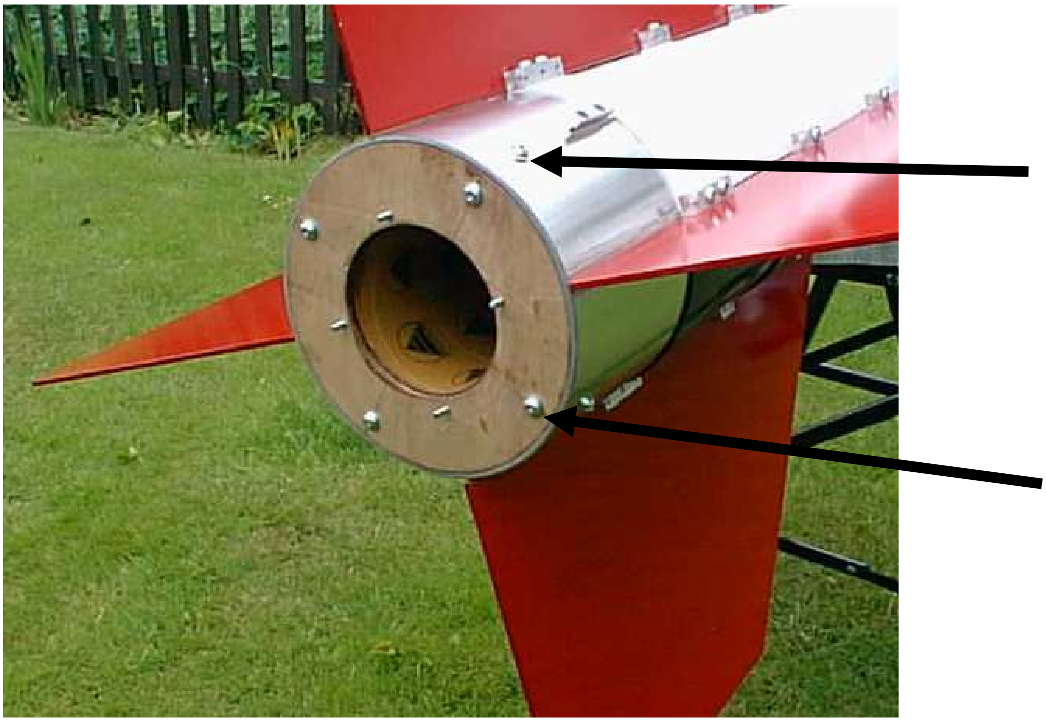
Motor mount centre centring ring

Motor mount rear bulkhead 18mm ply

Image shows the scale fin mounting brackets.

The Dibond fins are bolted to the airframe with square section aluminium extrusions. Bolts are all 6mm. Spreader plates are used internal to the body tube to prevent flexture and spread the load.
6 brackets are used for each fin. Fins and brackets may be removed for inspection and repair.

One of 4 x through the side motor mount bolts (6mm)

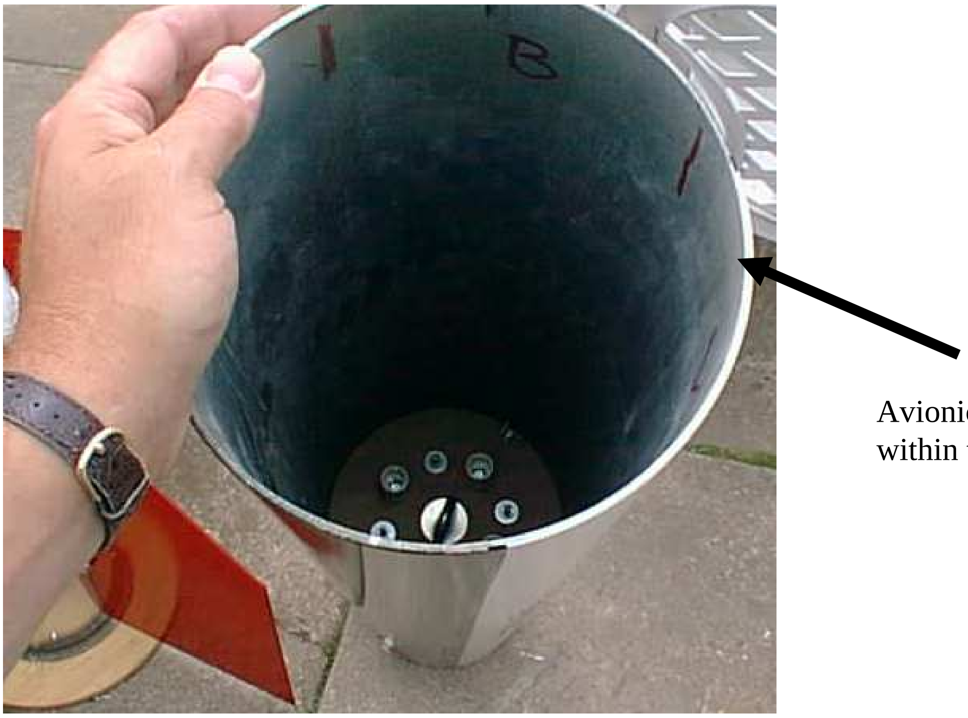


The motor mount is bolted into place with 4 x internal aluminium angle brackets. These brackets are held in place by 2 x 6mm bolts each. This provides a very strong motor mount that may be inspected if required.

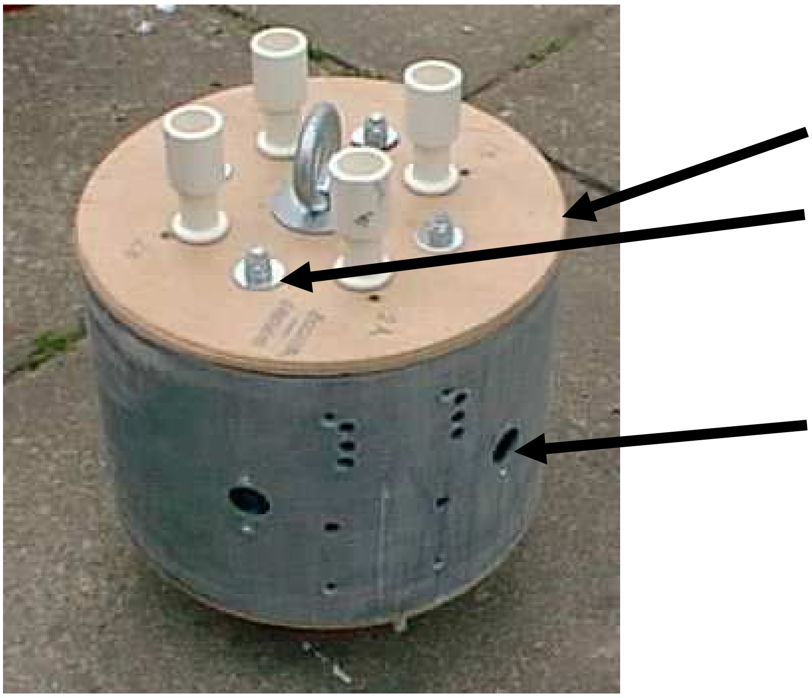
Image shows the rear motor mount (18mm ply bulkhead) and the 4 x 4mm bolts to hold the Hypertek in place.
The standard large diameter retainer supplied shall be used to retain the motor

Image shows the custom launch lugs that will be used on the launch rail.

Each lug (2 are used) is held in place by two 3mm countersunk caphead screws.
Spreader washers and nuts are used internally.



Avionics bay in place
within the centre section



Plywood bulkheads either die of avionics bay held in place by 6 x 6mm threaded rod.

Eyebolts either side of avionics bay for attaching main and drogue quick-links.

Holes in the side of the avionics bay are for 2 x Gwhizz units and on/off switches for each unit.

The on/off switches are accessible with the avionics bay in place.

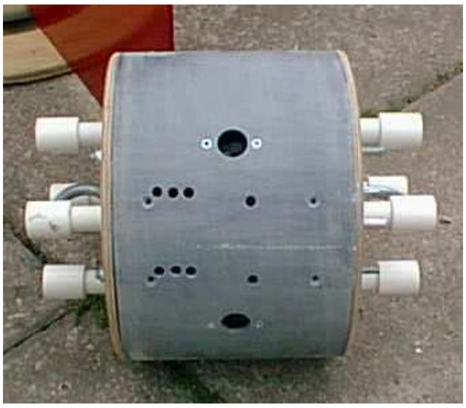


Image shows 4 x deployment charges either side of the avionics bay. 4 x for main and 4 x for drogue.

Overview of nose cone above. The nose cone is turned from pink foam.

A wooden dowel runs through the centre of the nose cone to hold the foam together and to give it strength. The dowel allows for firm joint (using epoxy) to a wooden bulkhead that is firmly glued into the plastic lower section of the nose cone.

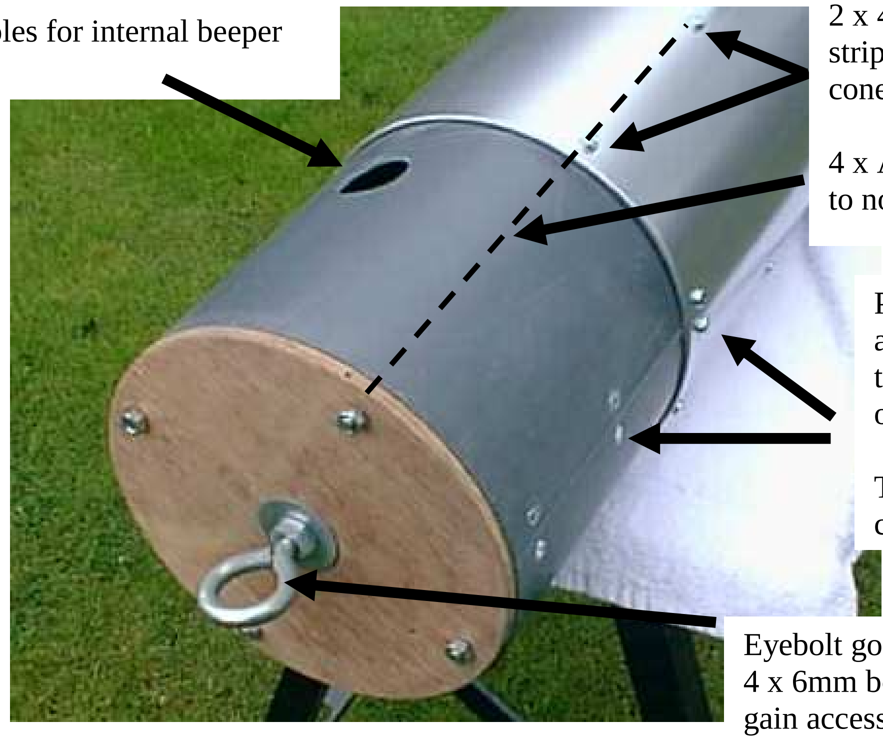


Image of the IRIS at lift off at KLOB 2005 under M1010 and 2 x J330 power

First Level 3 flight attempt:-

The first attempt at KLOB 2005 was unsuccessful. The rocket was damaged during recovery and has not flown since.

The damage sustained during the 1st attempt was due to a freak in flight collision during deployment of the drogue chute. The harness was severed in the collision causing separation near apogee.

The main chute opened successfully and recovered the payload and nose cone relatively undamaged. I have rebuilt the rocket with a stronger harness for the 2nd attempt. This now uses tubular Kevlar.

The rocket has been rebuilt and checked for damage sustained in the first flight. New body tubes sections have been added and one centering ring has been replaced.

The next flight is due to be over the IRW week in late August 2007 at Fairlie Moor

Documentation has been sent to Richard Osborne and a spare copy will be made available to the RSO at the site prior to the launch.

Motor configuration:-

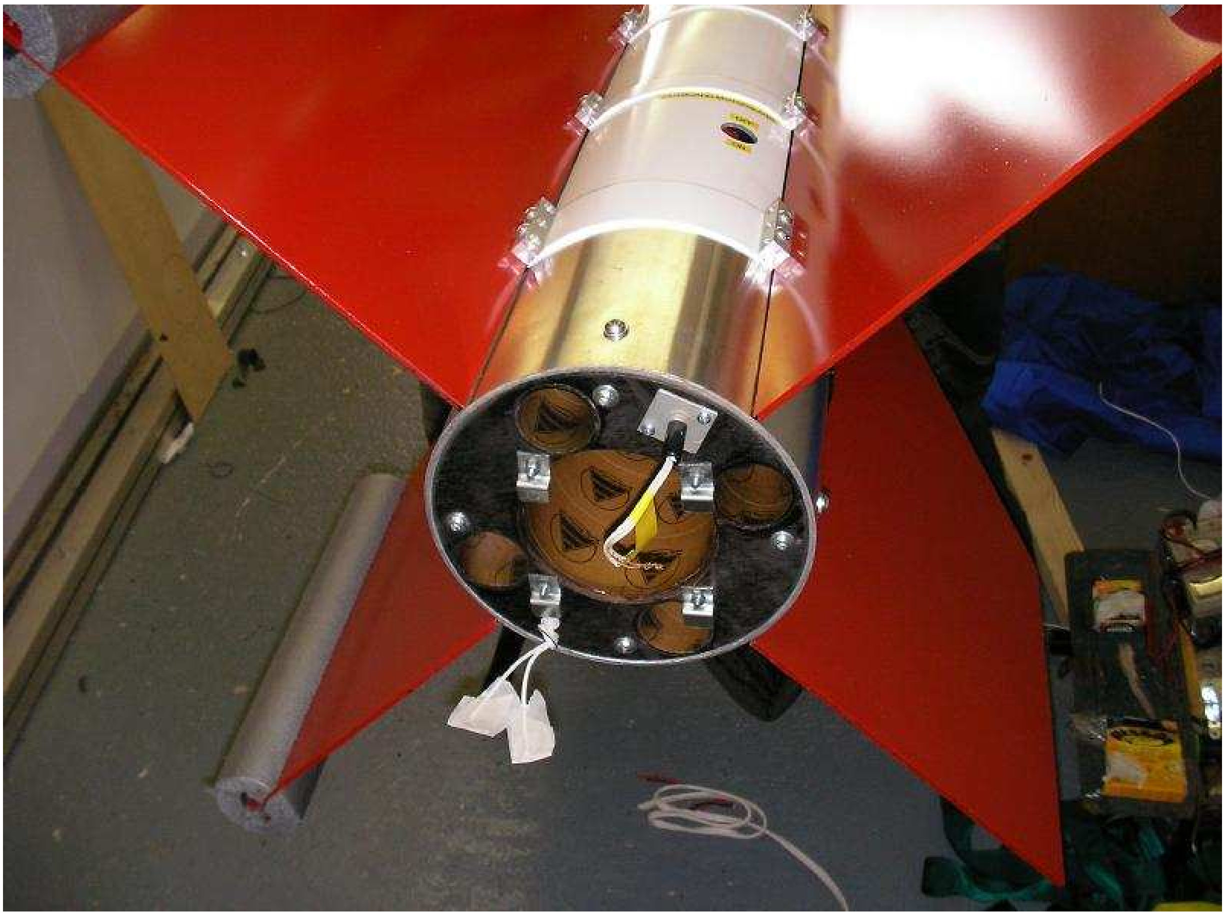
Motor configuration will be the same using the HyperTek Armageddon M1010 and 2 x J330 Cesaroni reload able motors.

This motor configuration is slightly different that in the original issued documentation, but will be same as issued to S&T before the first flight.

The single M Armageddon is sufficient for a safe flight, but the 2 x J330 motors provide additional thrust at lift off to provide some additional thrust to ensure an initial straight flight. These are initialed by a pull jack after ignition of the hybrid and movement of the rocket on the pad.

The initial flight attained an altitude of 7350 feet AGL with the motor configuration stated here. The original calculate altitude using the single Hybrid was 7107 feet AGL. See calculate altitude below.

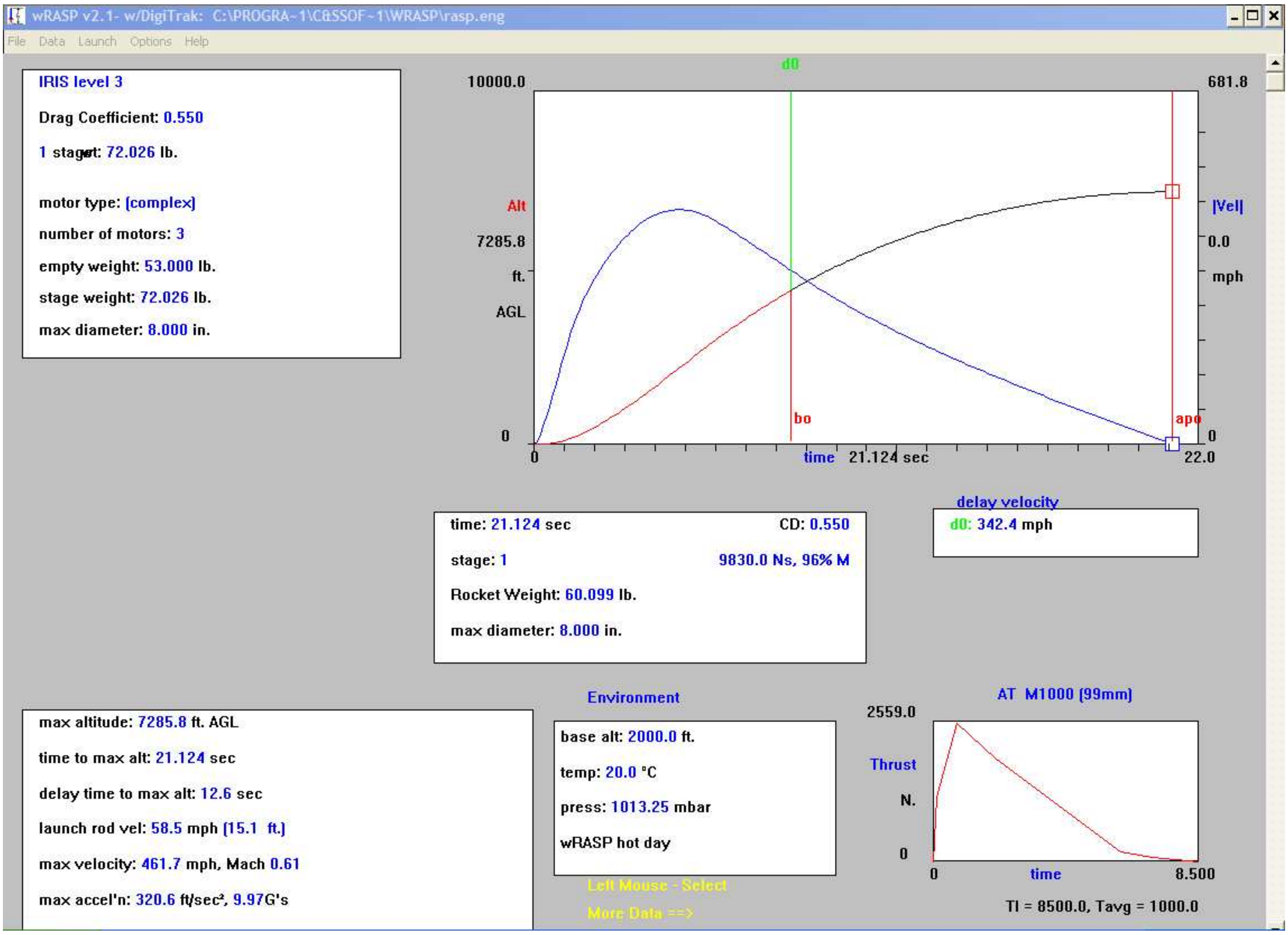
A safety switch and beeper are employed to prevent inadvertent arming of the system on the pad. See images below:-



Above image shows the 4 outboard motor mountings. Only 2 are used for the flight. The outboard motors ejection systems are removed and have no effect on parachute ejection. The two GWizz units perform this function.

Above image shows the outboard motor arming system, and dual beepers. One for outboard motor ignition warning and the other for recovery. Both are on separate battery systems.

The original software used to calculate the flight has been lost, the above screen shot shows the simulated rocket with a very similar configuration, motors and launch weight. This shows a maximum altitude of 7285 feet AGL.



Arming the system:-

Arming the system is a little more complex that launching a single Hybrid motor. The arming sequence to support the fill sequence in the above documentation is given below.

1. All motors are loaded without igniters (except for the Hypertek) before being loaded onto the launch rail.
2. The pull jack is installed and tied to the launch pad. The outboard motor safety switch is checked to be off and not sounding
3. The hybrid motor fill stem is loaded into position as in the procedure in the above document and secured.
4. Igniters are loaded into the solid outboard motors and wired to the ignition system. Spaer cable is secured.
5. The range is cleared.
6. Clearance is gained from the RSO by the person doing the launch (myself) to arm the systems. No other personnel are allowed to approach the launch pad.
7. Both the GWhiz units are armed
8. The video camera is armed
9. The pull jack is checked again and also that there is no beep for the ignition system
10. The outboard motor ignition system is armed and I return to the launch controller
11. Ignition sequence is begun upon confirmation that it is ok to launch by the RSO